A Fast Technique for the Creation of Large-Scale High-Resolution IRAS (HIRES) Beam-matched Images

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ABSTRACT

HIRES processing provides a significant improvement in both resolution and image quality over previous IRAS image products, but the characteristics of the HIRES beam make accurate comparisons between the various IRAS bandpasses and between HIRES data and data at other wavelengths non-trivial. We present a new, fast technique for the construction of HIRES beam-matched images that is especially well suited for the creation of large-scale (several square degrees) ratio maps. Other techniques for the construction of ratio maps are discussed and compared with the new algorithm. Examples of the large-scale ratio maps that can be constructed using this new technique are presented. The algorithm's application to the construction of multiwavelength difference images and multi-colour images is also demonstrated.

Subject headings: techniques: image processing — infrared: general — dust — surveys

1. INTRODUCTION

Often one would like to create beam-matched maps of IRAS images in order to study the properties of the emitting grains and the incident radiation field. For example, the ratio between the IRAS 60 and 100 μm bands provides a measure of the equilibrium dust temperature and is often used as a proxy for the intensity of the radiation field (Helou et al. 1991). The 12/100 μm ratio and 12/25 μm ratio can be used to trace abundance variations in different grain populations (e.g., Boulanger et al. 1990; Ryter, Puget, & Pérault 1987). In order to use any such ratio image

for quantitative purposes it is important that the beam shape of the two images be well matched. The most commonly used IRAS image data product for such studies is the IRAS Sky Survey Atlas (ISSA) (Wheelock et al. 1994). With the ISSA the construction of ratio maps does not pose a significant problem since all four IRAS bands have been brought to a common resolution of $4' \times 5'$. Drawbacks to using these images include the presence of striping and the relatively low resolution.

HIRES processing[1] (Aumann, Fowler, & Melnyk 1990) can yield much higher spatial resolution and, with the addition of new destriping and zodiacal subtraction algorithms (Cao et al. 1996), superior image quality. However, there are a number of characteristics of the resulting images that make the creation of an accurate ratio map non-trivial: the achieved resolution is different in each band for a given number of iterations, the beam shape varies between bands primarily because of the difference in the detector sizes, and within each band the beam shape also varies as a function of position because of the varying IRAS scan pattern on the sky (Cao et al. 1997; Kerton & Martin 2000). These image characteristics mean that a simple ratioing of the HIRES images is not satisfactory in the majority of cases.

Various techniques have been developed to create accurate high resolution ratio maps with HIRES data. As will be discussed, most existing techniques for creating HIRES ratio maps tend to be time consuming, and in some cases also require access to the raw IRAS data. The creation of a new fast technique is primarily motivated by the existence of two very large HIRES data sets that cover parts of the Galactic plane. The IRAS Galaxy Atlas (IGA[2]; Cao et al. 1997) consists of 1$^{\rm st}$ and 20$^{\rm th}$ iteration far-infrared (60 and 100 μm) images and ancillary files covering the entire Galactic plane between $b = \pm 4.7^{\circ}$. The Mid-Infrared Galaxy Atlas (MIGA[3]; Kerton & Martin 2000) is the equivalent mid-infrared data set (12 and 25 μm) covering $l = 74^{\circ} - 148^{\circ}$; $b = \pm 6.5^{\circ}$. Both of these data sets have been incorporated as large $5.12^{\circ} \times 5.12^{\circ}$ mosaics into the Canadian Galactic Plane Survey (CGPS[4]; Taylor 1999) an international project that is conducting a multiwavelength (21-cm HI line, 1420 and 408 MHz continuum, CO (J$= 1 - 0$), and infrared) survey of the Galactic plane at a common spatial resolution of $\sim 1'$. The existence of this large uniform data set means that high-resolution studies of dust in the ISM can now be easily done over very large spatial scales.

In Section 2 we review the various techniques that have been used to create ratio maps of HIRES images. A new technique developed specifically for the fast creation of large-scale HIRES ratio maps is presented in Section 3 and the resulting ratio maps are examined in Section 4. Section 5 presents some sample applications of the new technique, and conclusions are given in Section 6.

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[1]HIRES images and ancillary files are available as single fields ($1^{\circ} - 2^{\circ}$ in size) through the Infrared Processing and Analysis Center (IPAC)

[2]IGA images are available at http://irsa.ipac.caltech.edu/applications/IGA/

[3]MIGA images are available at http://www.cita.utoronto.ca

[4]CGPS data are available at the Canadian Astronomy Data Centre (CADC; http://cadcwww.hia.nrc.ca)

2. PREVIOUS RATIO MAP CREATION TECHNIQUES

2.1. Simple Division

The similarity in the size and layout of the 12 and 25 μm detectors in the focal plane array of IRAS (IRAS Explanatory Supplement 1988) means that the resulting beam shapes are very similar and two-dimensional Gaussian fits to the beams will often agree to within the fitting errors. Beam maps showing the HIRES beam shape at various locations in the image and tables of two-dimensional Gaussian fits to the beam shape are available as part of the HIRES service at IPAC and are also included in the IGA and MIGA releases. This similarity in beam shape means that, with care, high resolution ratio maps can be created by simply dividing the 12 and 25 μm images. Care is required because, although the beam shapes are very close, the actual beam shapes are not two-dimensional Gaussians and can vary in detail because of differences in the ratio between the point source flux and the background level during HIRES processing between the two images (see Section 4.1 of Kerton & Martin 2000 for details). As an example, Figure 1 shows two ratio maps of the region around the HII region Sh 2-151, chosen because of the unusual irregular cross-shaped beam pattern caused by the significant difference in the scan angle between the two IRAS coverages of the region (this effect is most noticeable at high ecliptic latitudes). The top image was constructed by simply dividing a 12 μm image from the MIGA by the corresponding 25 μm MIGA image, while the bottom image was constructed using the cross-band simulation technique (see Section 2.4 for details) to bring the two images to a common beam shape. In general the structure shown in each image is the same, but note that the point sources are more clearly defined in the bottom image because of the matching beam shapes. For example, the feature associated with Sh 2-151 is more clearly shown to be a point source in the beam-matched image than in the simple ratio image. The lower image also has a less mottled background due to the matched beams and the slightly lower resolution. The beneficial effect of bringing the two images to the same beam shape is seen in the way that the cross-shaped beam pattern of the point sources seen in Figure 1 is undistorted in the cross-band simulator ratio image while in the simple ratio map the point sources show some non-physical structure. Most of the point sources (stars) in the ratio image saturate and appear as black structures since they are brighter at 12 μm than at 25 μm. The two noticeable exceptions are the point source associated with Sh 2-151 at $l = 108.5°$, $b = -2.8°$ and the point source at $l = 107.6°$, $b = -2.24°$ (the planetary nebula PK 107−2.1).

For some purposes a simple 12/25 μm ratio map, such as that shown in Figure 1, may suffice. The user needs to closely inspect the associated beam maps to determine if the beam shapes are close enough for their purposes. If so, the similar beam shape and resolution of the mid-infrared bands provides a quick and easy way to obtain high resolution mid-infrared ratio maps. Note that any simple ratio map involving the 60 and 100 μm bands will not be satisfactory because of the large difference in beam resolution and shape, and some form of beam matching will be desirable. This is the focus of the rest of this paper.

2.2. Convolving to Common Lower Resolution

One simple technique that is often used is to smooth the HIRES images to a common lower resolution. For example, Xu & Helou (1996), in their study of M31, convolve their HIRES images to a common $1.7'$ circular beam (their lowest original HIRES resolution) in order to construct ratio images. This technique is fast and does not require access to the original IRAS data (just the HIRES beam tables), but suffers from the disadvantage that one is losing much of the resolution gained by the HIRES processing. This can especially be a concern for the mid-infrared bands where one can achieve very high resolution (the original resolution of the 12 and 25 μm images from Xu & Helou (1996) was $0.5' \times 0.9'$). Over very large areas, where the beam properties are expected to change significantly, one also has to take care to use the correct convolving kernel to smooth the beams correctly. If the smoothing is very large, this is not a major concern, but again one loses some of the advantage of using HIRES in the first place.

2.3. Variable HIRES Iteration

This technique takes advantage of the fact that the resolution achieved by HIRES processing improves as the number of iterations increases. By stopping the HIRES processing at different iterations for data at different wavelengths one can obtain approximately matching resolution in different bands (e.g., see the Wang 1994 study of the supernova remnant IC 443). The exact beam shape can still be slightly different so the final images are often convolved to a circular beam to reduce this effect (Wang 1994). Since this technique requires some degree of trial and error to match the beam resolution in the different bands it is really only suitable for mapping small areas and for users that have easy access to both the raw IRAS archive and the HIRES processing software (YORIC)[5].

2.4. Cross-Band Simulation

The most accurate technique for matching the various HIRES beams is called cross-band simulation (Fowler & Aumann 1994). This technique makes use of the HIRES IRAS simulator that is part of the YORIC software package. Using this technique, if one wanted to create a ratio map of a 12 and 60 μm image, the simulator would be used to scan the 12 μm HIRES image with the 60 μm detector pattern to create simulated data for the 12 μm sky. These "observations" would then be HIRES processed as if 60 μm data to create a somewhat lower resolution version of the 12 μm image. The same process is followed for the 60 μm data. The final result is two images at the same resolution (in this example, each slightly poorer than the original 60 μm HIRES resolution).

[5]The archive and software are available at IPAC and at the Canadian Institute for Theoretical Astrophysics (CITA)

The major advantage of this technique is that because the resulting beams are very well matched at every location in the image, spurious results are not introduced into the ratio maps. This technique is very time consuming since the HIRES algorithm is essentially run twice for each field that needs to be processed. Simulator images can be requested from IPAC for single fields so a user in principle does not need direct access to the YORIC software or the IRAS data archive for single field images. If one is interested in creating large scale images (such as the large mosaics that can be created with the IGA and MIGA data) then access to the YORIC software and the IRAS data archive is essential since large scale mosaics cannot be created by simply patching together smaller images obtained from IPAC because of the local destriping algorithms that are used. Both the MIGA and IGA are on a common grid and were created using a special pre-processing technique that allows the easy creation of high-quality large-scale mosaics (e.g., see Cao et al. 1997 or Kerton & Martin 2000).

3. NEW ALGORITHM

Since the typical user of the MIGA, IGA, and/or CGPS data will not have access to either YORIC or the raw IRAS data it is important to have a robust technique that users can apply to the data that they do have in order to construct ratio maps. The criteria used in the development of this new technique are that it should make use of only those data available to the typical user, it should be fast, and it should result in images that are close to what the cross-band simulator technique would produce.

As mentioned above, the resolution and position angle of the HIRES beam varies as a function of position over an image. As part of the standard MIGA and IGA releases two-dimensional Gaussian fits were made to the beam shape and recorded in accompanying files. This information is also available for individual HIRES processing requests. The basic assumption underlying the new ratio map technique is that the HIRES beam is well described by the two-dimensional Gaussian at the various points in the images. Clearly this assumption works best in those regions where the beam shape is "well-behaved". In the worst case, in regions of high ecliptic latitude, the beam shape can even have X-shaped wings due to very large variations in the scan angle of the IRAS satellite. At these locations, while the assumption is clearly dubious, the resulting ratio maps turn out to still be useful. This is because the central part of the X-shaped beam is still well described by the Gaussian approximation.

We describe the operation of the algorithm on a single standard HIRES field that one would obtain from either the IGA or the MIGA. In order to build up a large scale image, one would repeat the technique for a number of fields then mosaic the images together. In a standard $1.4^\circ \times 1.4^\circ$ field, beam information is reported in a 7×7 array of points spread evenly over the image. This sampling interval does greatly undersample the beam variation across the image, but finer sampling was not possible because of the way the beam maps are constructed. The algorithm assumes that the beam information describes the beam shape over the $0.2^\circ \times 0.2^\circ$ region surrounding each beam. The

validity of this assumption depends upon how little the scan pattern changes over the $0.2^\circ \times 0.2^\circ$. Users can determine this by either looking at the beam maps or the detector track maps that are included in the standard MIGA and IGA releases and in a typical HIRES request.

The algorithm runs as follows. To start, one has two images, image 1 and image 2, at IRAS band 1 and band 2 respectively. The major and minor FWHM and orientation for the beams in image 2 is read from a file the user has prepared from the HIRES beam tables. For each beam a two-dimensional Gaussian kernel is created and convolved with a $0.4^\circ \times 0.4^\circ$ region centered on that beam that has been clipped out of image 1. The size of the area clipped out was chosen to provide ample room to avoid edge effects when doing the convolution. The $0.2^\circ \times 0.2^\circ$ center of the convolved region is clipped out and placed in the final convolved image. The procedure is repeated until all 25 beams in the 1° center of the image have been processed and the $1^\circ \times 1^\circ$ convolved image has been built up. Beams centered 0.1° from the outer edge of the image are ignored since they correspond to a 0.2° border that should be clipped off the final images before mosaicing, or making ratio maps (this buffer zone was included in the HIRES processing to avoid problems with artificially low detector coverage). The entire procedure is then repeated using image 2 and the beam data for image 1.

Essentially the new algorithm is a combination of the smoothing technique discussed in Section 2.2 and the cross-band simulator technique described in Section 2.4. However, instead of scanning the image with the IRAS beam shape and detector scan pattern it uses a two-dimensional Gaussian convolution to match the beam shapes based upon the information provided in the beam maps and tables. Also, instead of smoothing to a markedly lower resolution it convolves the image only to the degree necessary to match the two images. The algorithm was implemented using IDL because of its matrix manipulation capability, but could easily be modified to any computer language[6].

While this algorithm was developed for and initially applied to IRAS HIRES data there is nothing about it that restricts its use solely to infrared data. The algorithm could be easily applied to, for example, an infrared and a radio data set provided sufficient information about the beam shapes was available (see Section 5). Large-scale radio spectral index maps can also be created using the algorithm. A specialized version of the algorithm (called MOSCONV, for MOSaic CONVolve) has been developed independently by L. Higgs at DRAO to create large-scale ($\sim 5^\circ \times 5^\circ$) spectral index maps using the 1420 MHz and 408 MHz data and ancillary files contained in the CGPS.

4. TESTS & COMPARISONS

The algorithm was tested on two regions with markedly different HIRES beam shapes. In each case three sets of images and beam maps were created: regular HIRES, cross-band simulated

[6]IDL code is available from C.R.K. upon request

HIRES, and HIRES processed with the new algorithm. The images allowed us to compare the relative quality of the resulting ratio maps while the beam maps allowed us to compare in more detail how the beam shape changes in each case. For the beam comparisons we focused on the 12 and 100 μm HIRES beams since they have the greatest difference in resolution and beam shape.

First we looked at a field (centered at $l = 189.0^\circ$, $b = 3.0^\circ$ near IC 443, see Figure 2) where the HIRES beam is "regular", i.e. it is very close to a two-dimensional Gaussian.

Figure 3 shows one-dimensional cuts through the minor axis (at the same position angle) of the 12 and 100 μm beams located at $l = 189.0^\circ$, $b = 3.0^\circ$ along with the absolute value of the difference between the two beams. The beam profiles have been normalized to the same central intensity so that differences in the beam shapes can be highlighted. Notice the large difference in the beam shapes in the raw images (top profile in Figure 3). Negative rings are evident in the 100 μm beam; this is a well known artifact of HIRES processing (Cao et al. 1997). The middle profiles show the beams that are created using the algorithm presented in this paper. The match between the beams is greatly improved from the original images. Finally the lower cuts show the beams that are formed in the cross-band simulation process. There is a significant improvement over the regular HIRES beams and even the ringing around the center of the beam is well matched in this case.

To illustrate the quality of the match in two dimensions, the upper row of Figure 4 shows surface plots of the absolute difference between the 12 and 100 μm beams for the regular HIRES, convolution, and cross-band simulation processes for this region. Again there is a substantial, comparable improvement in the match between the beams evident in the convolution and cross-band simulation plots. The differences between the two beams for the cross-band simulation and convolution beams are of the same (small) magnitude.

The same tests were repeated in another field (centered at $l = 93.0^\circ$, $b = 4.0^\circ$, see Figure 5) where the HIRES beam has X-shaped wings (especially evident at 12 μm). The one-dimensional cuts through the various beams are shown in Figure 6. Again we see a significant comparable improvement in the agreement between the beam shapes both in the cross-band simulation and our new technique. The bottom row of Figure 4 shows the surface plots of the difference in the beam shape. These plots show that the convolution and cross-band simulation technique will provide similar degrees of improvement to the quality of the beam match.

Figure 7 shows the sum of the absolute difference between the 12 μm and 100 μm beams for all of the beams in the two areas we tested. The beam that has been discussed in detail is indicated on the figure, and clearly is a representative result. In all cases we see that the convolution algorithm yields a substantial improvement in the match between the two beams that is comparable to the results obtained using the cross-band simulation technique.

The resulting ratio maps created using our convolution technique and the cross-band simulation technique are shown in the bottom two frames of Figures 2 and 5. The only major difference between the two results is the detailed structure close to the point sources. The convolution map

is much faster to create than the cross-band simulation map and results in a final ratio map that is comparable in achieved resolution and overall image quality.

In order to compare the various ratio maps the rms fractional difference between the cross-band simulated and the unprocessed HIRES or convolution ratio image was calculated. This was also carried out for four subregions corresponding to various features in each image. Results from the comparison are presented in Tables 1 and 2 for various IRAS band combinations. As would be expected the convolved ratio map is a much better match to the simulated ratio map as indicated by the lowering of the rms fractional difference for all of the various IRAS band combinations. This quantitative assessment was combined with a visual inspection of the convolved ratio images and the simulated ratio images to make sure they were comparable overall.

5. SAMPLE APPLICATIONS

In Figure 8 we show an example of how this technique can be applied to the creation of large-scale infrared ratio maps. The upper image is the 12/100 μm ratio map of the W5 HII region created using ISSA images. The poor resolution and image quality (striping) referred to in Section 1 are apparent. The lower image is the same image constructed using HIRES data from the IGA and MIGA processed using our algorithm to match the 12 and 100 μm beam shape at all locations in the image. Clearly this image is more useful for any scientific investigation.

The region with a low 12/100 μm ratio that dominates the center of the map corresponds to the ionized gas in W5. The drop in this ratio relates to the destruction of PAH dust grains in the ionized regions which in turn causes a reduction in the 12 μm emission. The various dark points visible in this map are all HII regions as confirmed by inspection of the 1420 MHz continuum images in the CGPS database. Maps like this one can be easily compared with large scale data products at other wavelengths in order to investigate the properties of interstellar dust in different environments. Note that whenever anything unusual is found in a HIRES color map, no matter how the map was created, a detailed examination of the separate-band images is called for (e.g., aperture photometry, checking the noise and coverage maps, etc.).

Although we have focused on the construction of infrared ratio maps in this paper, another application of the new algorithm is the comparison of multiwavelength data sets using difference images or multi-colour imaging. In these applications the two datasets are first scaled and then either subtracted or displayed as different colours. This allows the relative distribution of the emission to be easily studied.

Figure 9 shows two of the typical $5.12^\circ \times 5.12^\circ$ mosaics from the CGPS database in the infrared (12 μm HIRES; left panel) and in 1420 MHz continuum (right panel). The object that dominates the center of the mosaic is LBN $140.77-1.42$. Comparison with CO and HI images of this region in the CGPS data base show that this region is an edge-on view of an HII-HI-molecular gas interface (a photodissociation region or PDR). We were interested in investigating the relative position of

the 12 μm emission and the 1420 MHz continuum emission at this interface. The beam shape in the 1420 MHz mosaic is also variable across the mosaic, so we created beam-matched images using the beam information provided in the CGPS database and the algorithm presented in this paper. Lower and upper data limits (peak 95% of image histogram) were selected that resulted in similar visual contrast in each image (as shown in Figure 9). Each image was then rescaled from 0 to 256 and the 12 μm image was subtracted from the 1420 MHz continuum image. The center panel of Figure 9 shows the resulting difference map. Dark areas are regions where the IR emission dominates, light areas are where 1420 MHz continuum emission dominates. Instead of subtracting the images one could also construct a two-colour image with the infrared data in the red channel and radio in the blue channel (for example). In this case we see that the intense 12 μm emission is coming mostly from a region just to the east of the intense continuum emission with a very slight overlap area. The PDR nature of the object is best seen by examining a cut through the region from east to west. Figure 10 shows a cut (background subtracted and normalized) from $l = 141.255°$, $b = -0.860°$ to $l = 140.130°$, $b = -0.965°$. The 12 μm emission peaks just inside of the 1420 MHz emission and then falls off in intensity as one moves farther into the neutral/molecular material to the east. This rapid increase in infrared emission at the ionized-neutral interface followed by a slow decline in emission as one moves into the neutral/molecular material is what one expects to see in a cross-section of a PDR (Teilens et al. 1993).

6. CONCLUSIONS

Beam-matched maps of HIRES IRAS data products have been shown to be useful both in studies of dust properties and in multiwavelength analyses of the dust and gas phases of the interstellar medium.

For images in any of the IRAS bands, simple ratio maps are seldom sufficient for any application beyond superficial inspection. For quantitative studies involving HIRES data some degree of extra processing is required.

To create high-resolution infrared beam-matched maps a simple, fast, convolution technique that makes full use of the beam shape information reported in the MIGA and IGA releases and also available as part of the standard HIRES request output has been developed. The algorithm provides a good match of the HIRES beams combined with a minimal loss of the resolution gained from using the HIRES processing technique.

We expect that this technique will be quite useful for the creation of very large scale (over many square degrees) infrared ratio maps for studies of the properties of dust in the ISM. The technique is also useful for the construction of multiwavelength difference or multi-colour images, and large-scale radio spectral index maps.

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Fig. 1.— Sh 2-151 Region. Comparison of ratio maps (12/25 μm) constructed using a simple division of MIGA images (top) and using the HIRES IRAS Simulator to perform cross-band beam matching (bottom). Images are linearly stretched from 0 (white) to 1 (black).

Fig. 2.— IC 443 Region. Comparison of ratio maps (12/100 μm) constructed using the HIRES simulator (bottom left) and using the convolution technique (bottom right) for a region with a regular HIRES beam (linear greyscale from 0.05 – 0.14, black–white with contours at 0.06 and 0.08). The top row shows the original HIRES images at 12 μm (left; linear greyscale from 2.1 – 9.2 MJy/sr, white – black) and 100 μm (right; linear greyscale from 10 – 120 MJy/sr, white – black).

Fig. 3.— Regularly shaped HIRES beam comparison. The solid and dot-dash lines show normalized cuts through the minor axis of a HIRES beam (100 and 12 μm respectively) located at $l = 189.0°$, $b = 3.0°$. The dashed line shows the absolute difference between the two beams. The regular HIRES and convolution results have been offset by 3 units and 1.5 units respectively.

Fig. 4.— HIRES beam absolute differences. The top row shows the absolute difference between the normalized 100 μm and 12 μm beams located at $l = 189.0°$, $b = 3.0°$. The bottom row shows the results for the irregular beams located at $l = 93°$, $b = +4.0°$. The differences for regular HIRES beams, the new convolution technique and cross-band simulation are shown from left to right. All of the surface plots are at the same scale. The beam images have been subsampled by a factor of 3 for clarity.

Fig. 5.— High Ecliptic Latitude Region. Comparison of ratio maps (12/100 μm) constructed using the HIRES simulator (bottom left) and using the convolution technique (bottom right) for a region with a HIRES beam with X-shaped wings (linear greyscale from 0.03 – 0.09, black–white with contours at 0.049 and 0.053). The top row shows the original HIRES images at 12 μm (left; linear greyscale from 3 – 7 MJy/sr, white – black) and 100 μm (right; linear greyscale from 50 – 135 MJy/sr, white – black).

Fig. 6.— High ecliptic latitude HIRES beam comparison. Like Figure 3 but for HIRES beams located at $l = 93.0°$, $b = +4.0°$.

Fig. 7.— The sum of the absolute difference between the 12 and 100 μm beams for all of beams in the two areas examined in this paper. The solid line is for the regularly-shaped beams and the dot-dash line is for the high ecliptic latitude beams that have X-shaped wings. The symbols indicate the beams that were used for the detailed comparisons shown in Figures 3, 4, and 6.

Fig. 8.— W5 12/100 μm ratio maps. Upper ratio map was constructed using ISSA images, lower ratio map was created using IGA and MIGA images processed with the algorithm described in this paper. Both maps are linearly stretched from 0.02 – 0.08 (black – white). Note the significant improvement in the image quality obtained by using the IGA and MIGA images. Dark areas (both extended and point source) correspond to regions of ionized gas where PAH grains are destroyed by the hard UV radiation field.

Fig. 9.— Large-scale multiwavelength comparison. A $5.12^\circ \times 5.12^\circ$ mosaic from the CGPS data base centered on $l = 140.75^\circ$, $b = -1.0^\circ$. The left and right panels show the original 12 μm ([MJy/sr]) and 1420 MHz ([K]) continuum emission mosaics respectively. The middle panel shows the result of scaling the beam-matched images from 0 to 256 and subtracting the infrared image from the radio image.

Fig. 10.— Infrared and radio continuum emission through the PDR LBN 140.77 − 1.42 (from $l = 141.255^\circ$, $b = -0.860^\circ$ to $l = 140.130^\circ$, $b = -0.965^\circ$; $18''$ wide; beam $\sim 1'$). The $\sim 1^\circ$ long slice was taken from beam matched versions of the images shown in Figure 9. Note the offset in the infrared and radio emission peaks and the sharp increase in the infrared emission followed by a more gradual decline.

Table 1. Ratio Image Comparison — Regular Beam

RAW−SIM Image[a]	Area 1	Area 2	Area 3	Area 4	All
	RMS Fractional Difference				
b1/b2	0.075	0.078	0.096	0.065	0.080
b1/b3	0.084	0.139	0.162	0.094	0.100
b1/b4	0.088	0.232	0.247	0.110	0.130
b2/b3	0.061	0.074	0.128	0.105	0.085
b2/b4	0.058	0.077	0.112	0.077	0.090
b3/b4	0.042	0.047	0.150	0.090	0.072
CON−SIM					
b1/b2	0.041	0.050	0.064	0.040	0.049
b1/b3	0.033	0.067	0.078	0.073	0.079
b1/b4	0.013	0.056	0.061	0.071	0.098
b2/b3	0.032	0.049	0.094	0.084	0.055
b2/b4	0.013	0.030	0.051	0.057	0.044
b3/b4	0.021	0.023	0.074	0.057	0.038

[a]b1 – 12 μm, b2 – 25 μm, b3 – 60 μm, b4 – 100 μm

Note. — RAW – no special processing; CON – convolution technique; SIM – cross-band simulation
Area 1 – featureless, Area 2 – around point source visible at 12 and 25 μm, Area 3 – around point source visible in all bands, Area 4 – edge of extended structure, All — entire image

Table 2. Ratio Image Comparison — Irregular Beam

RAW−SIM Image[a]	RMS Fractional Difference Area 1	Area 2	Area 3	Area 4	All
b1/b2	0.030	0.109	0.191	0.030	0.060
b1/b3	0.038	0.161	0.280	0.043	0.087
b1/b4	0.046	0.305	0.431	0.058	0.131
b2/b3	0.020	0.093	0.247	0.030	0.054
b2/b4	0.022	0.165	0.396	0.034	0.085
b3/b4	0.017	0.025	0.138	0.065	0.032
CON−SIM					
b1/b2	0.016	0.089	0.139	0.015	0.041
b1/b3	0.012	0.085	0.272	0.021	0.055
b1/b4	0.010	0.074	0.241	0.016	0.049
b2/b3	0.010	0.035	0.192	0.022	0.037
b2/b4	0.007	0.032	0.160	0.015	0.031
b3/b4	0.007	0.008	0.044	0.017	0.011

[a]b1 – 12 μm, b2 – 25 μm, b3 – 60 μm, b4 – 100 μm

Note. — RAW – no special processing; CON – convolution technique; SIM – cross-band simulation
Area 1 – featureless, Area 2 – around point source visible at 12, 25, and 60 μm, Area 3 – around very bright point source visible at 12, 25, and 60 μm, Area 4 – around point source visible in all bands, All — entire image

This figure "fig5.jpg" is available in "jpg" format from:

http://arXiv.org/ps/astro-ph/0103356v1